ORNL/CDIAC-145

Carbon Dioxide Information Analysis Center

World Data Center for Atmospheric Trace Gases

Fiscal Year 2003 Annual Report

http://cdiac.ornl.gov/

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Carbon Dioxide Information Analysis Center
and
World Data Center for Atmospheric Trace Gases

Fiscal Year 2003
Annual Report

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Environmental Sciences Division

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1. Introduction

The Carbon Dioxide Information Analysis Center (CDIAC), which includes the World Data Center (WDC) for Atmospheric Trace Gases, is the primary global change data and information analysis center of the U.S. Department of Energy (DOE). More than just an archive of data sets and publications, CDIAC has, since its inception in 1982, enhanced the value of its holdings through intensive quality assurance, documentation, and integration. Whereas many traditional data centers are discipline-based (for example, meteorology or oceanography), CDIAC's scope includes potentially anything and everything that would be of value to users concerned with the greenhouse effect and global climate change, including atmospheric concentrations and emissions of carbon dioxide (CO_2) and other radiatively active gases; the role of the terrestrial biosphere and the oceans in the biogeochemical cycles of greenhouse gases; long-term climate trends; the effects of elevated CO_2 on vegetation; and the vulnerability of coastal areas to rising sea levels.

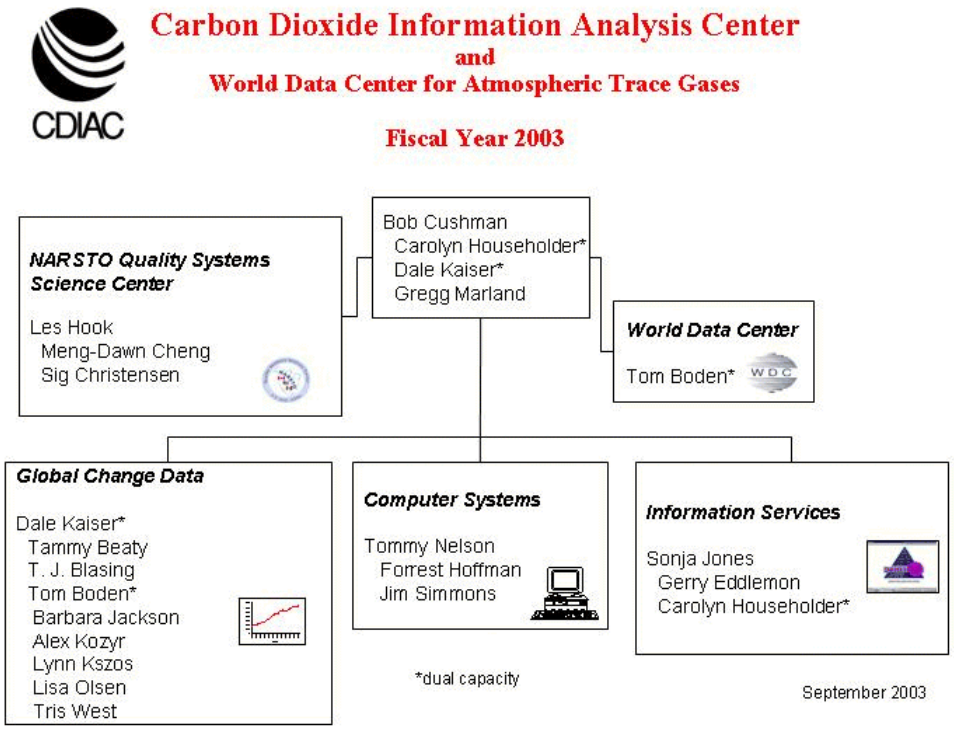
CDIAC is located within the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. CDIAC is co-located with ESD researchers investigating global-change topics, such as the global carbon cycle and the effects of carbon dioxide on climate and vegetation. CDIAC staff are also connected with current ORNL research on related topics, such as renewable energy and supercomputing technologies.

CDIAC is supported by the Climate Change Research Division (Jerry Elwood, Director) of DOE's Office of Science, Biological and Environmental Research Program. CDIAC represents DOE in the multi-agency Global Change Data and Information System (GCDIS). Wanda Ferrell is DOE's Program Manager with overall responsibility for CDIAC. Roger Dahlman is responsible for CDIAC's AmeriFlux tasks and Anna Palmisano for CDIAC's Ocean Data tasks.

CDIAC is made up of three groups (Data Systems, Information Services, and Computer Systems), as well as the World Data Center for Atmospheric Trace Gases and the NARSTO Quality Systems Science Center, with 20 full-time or part-time staff (see Fig. 1.1). The following section provides details on CDIAC's staff and organization.

- The Data Systems Group identifies and obtains databases important to global-change research; analyzes data; compiles needed databases; provides data management and support to specific programs [e.g., NARSTO, Free Air CO_2 Enrichment (FACE), AmeriFlux, Oceans]; and prepares documentation to ensure the long-term utility of CDIAC's data holdings.
- The Information Services Group responds to data and information requests; maintains records of all request activities; analyzes user statistics; assists in Web development and maintenance; and produces CDIAC's newsletter (*CDIAC Communications*), the annual reports, and various information materials.
- The Computer Systems Group provides computer system support for all CDIAC and WDC activities; designs and maintains CDIAC's computing system network; ensures compliance with ORNL/DOE computing security regulations; ensures long-term preservation of CDIAC data holdings through systematic backups; evaluates, develops, and implements software; ensures standards compliance; generates user statistics; provides Web design, development, and oversight; and provides systems analysis and programming assistance for scientific data projects.

Figure 1.1 CDIAC Organizational Chart.



1.1 Our Philosophy

Our philosophy can be expressed in terms of five interrelated principal objectives:

- Focus on the data and information products that are most in demand by our diverse user community of researchers, educators, students, policymakers, corporate officials, and the interested public. These products include the landmark record of rising atmospheric CO_2 at Mauna Loa, Hawaii; long-term U.S. global climate data; and global, regional, and national CO_2 emissions from fossil-fuel combustion.
- Emphasize data quality so that our understanding of global climate change is based on reliable information.
- Thoroughly document important databases so that 20 or more years from now, users (especially those who are not experts in the particular disciplinary area) will be able to understand how a database was produced and what the data mean.
- Provide proper credit to data contributors so that our users will understand that the data they receive from us originated not with CDIAC but rather with the investigators who so generously chose to share their data with CDIAC and a wider scientific community.
- Offer data and information to all users without restriction or charge so that society receives the greatest possible benefit from the originating research programs. Take advantage of current developments in computing technologies for data archival and distribution so that we provide a secure home for important data and provide the information to our users in the format most appropriate for them. At the same time, CDIAC appreciates that many users still prefer to receive information in more traditional formats, and we do our best to accommodate the diversity in the needs of our user community.

1.2 CDIAC Staff Listing

CDIAC Staff in FY 2003

Staff	Phone no. (Area code - 865)	Internet address (@ornl.gov)	Function
Tammy Beaty	574-0119	beatytw	GIS Specialist
T. J. Blasing	574-7368	blasingtj	Meteorologist/Statistician
Tom Boden*	241-4842	bodenta	Director, WDC, Atmospheric Trace Gases; Ecologist
Meng-Dawn Cheng	241-5918	chengmd	NARSTO QSSC Chief Scientist; Atmospheric Chemist
Sig Christensen	574-7394	christensen1	NARSTO Data Analyst; Ecologist
Bob Cushman	574-4791	cushmanrm	Director, CDIAC; Ecologist
Gerry Eddlemon	574-7337	eddlemongk	Environmental Scientist
Forrest Hoffman	576-7680	hoffmanfm	World Wide Web Specialist;
Les Hook	241-4846	hookla	NARSTO QSSC Director; Ecologist
Carolyn Householder*	576-2118	householdecr	Information Services; CDIAC Administrative Support
Barbara Jackson[a]	574-8680	jacksonbl	Computer Scientist
Sonja Jones	574-3645	jonessb1	Task Leader, Information Services
Dale Kaiser*	241-4849	kaiserdp	Task Leader, Global Change Data; Meteorologist
Alex Kozyr	576-8449	kozyra	Oceanographer
Lynn Kszos*	574-4784	kszosla	Biologist
Gregg Marland	241-4850	marlandgh	Senior Scientist; Geologist
Tommy Nelson[b]	574-0769	nelsontr	Task leader, Computer Systems; Computer Scientist
Lisa Olsen	241-5921	olsenlm	Geographer; GIS Specialist
Jim Simmons[c]	574-1060	simmonsjw	Workstation Specialist; Computer Scientist
Tris West*	574-7322	westto	Agronomist

[a] Computer Science and Mathematics Division, ORNL
[b] Computational Sciences and Engineering Division, ORNL
[c] Networking and Computing Technologies, ORNL
*Dual Capacity

2. Focus Areas

2.1 AmeriFlux

(*http://public.ornl.gov/ameriflux/Participants/Sites/Map/index.cfm*)

Noteworthy Developments during FY 2003

The AmeriFlux data archive continues to grow and at the end of FY 2003, the collection included over 210 site-years of data from 53 sites covering the period 1991-2003. Collectively, over 37 million data values are available from the AmeriFlux data archive at CDIAC.

AmeriFlux data, information, and presentations continue to be very popular. Over 350,000 files including data files, graphics images, and tabular listings have been retrieved from the AmeriFlux WWW site since August 2001, which marks the time when a revised AmeriFlux site was launched on a new server at ORNL. During FY 2003, approximately 30,000 unique computer systems accessed AmeriFlux data on the CDIAC FTP server.

FY 2003 was a busy and productive year in efforts to support the AmeriFlux data archive. Efforts were expended in all facets of our AmeriFlux data-support effort including networking, data processing, compiling data, assisting analyses, data dissemination, and WWW development.

Numerous meetings were attended during FY 2003 by AmeriFlux staff where presentations were made highlighting AmeriFlux data activities including the AmeriFlux annual science meeting (October 2002, Boulder), Climate Change Science Program Workshop (December 2002, Washington, D.C.), AGU annual fall meeting (December 2002, San Francisco), and the North American Carbon Program Implementation Workshop (May 2003, Washington, D.C.).

To help promote proper data submission to the AmeriFlux data archive, Tom Boden developed AmeriFlux data submission guidelines. The guidelines were reviewed by the AmeriFlux Science Steering Committee, modified slightly based on their comments, and posted on the AmeriFlux WWW site (*http://public.ornl.gov/Standards/AmeriFluxDataSubmission.doc*).

Dr. Lianhong Gu joined ORNL in the summer of 2002 so last year marked Lianhong's first full year at ORNL and as part of the AmeriFlux data activity. Lianhong devotes approximately 25% of his time to AmeriFlux and FLUXNET data activities. Lianhong's initial AmeriFlux work has focused on data analysis and developing a statistics-based approach for adjusting nighttime flux measurements using friction velocities (U*). Lianhong's analysis looking at enhanced photosynthetic responses at one AmeriFlux site (Harvard Forest) following the 1991 Mt. Pinatubo eruption due to increases in diffuse radiation was published in the March 2003 issue of Science. In addition to the primary findings, the paper helps draw attention to the need to include additional radiation measurements, like diffuse radiation, into the core suite of measurements made by the AmeriFlux measurement community. Significant strides were also made in the development of the Moving Points Test (MPT), a statistics-based approach to adjust nighttime flux measurements using U* thresholds. During FY 2003, the MPT program was successfully written and tested using both artificial data and actual data from four AmeriFlux/FLUXNET sites (Harvard Forest, the tallgrass prairie site in Oklahoma, an aspen forest site in Canada, and a pine forest site in Scandinavia). The MPT approach was presented by Lianhong at the 2003 AmeriFlux science meeting (October 2003, Boulder) and a draft Gu et al. manuscript

has been prepared and will be submitted to the journal Agricultural and Forest Meteorology in early 2004.

One of the ongoing activities at the AmeriFlux data archive are efforts to assemble detailed site characterizations and ancillary data sets for AmeriFlux sites. Among the information sought for individual sites include land-use histories, stand ages, rooting depths, and detailed estimates of carbon and nitrogen stocks (root carbon content). Attempts to secure ancillary data sets, not routinely submitted by AmeriFlux sites to the archive, like leaf area indices and soil respiration measurements from soil chambers have often proven difficult. In response to the growing need for "site characterization" information, especially within the North American Carbon Program (NACP), Tom Boden developed a successful proposal to the FY 2003 DOE Terrestrial Carbon Processes (TCP) program to assemble "site characterizations" in support of NACP research in the Upper Midwest Region of the United States.

We continue to support the AmeriFlux/Model/MODIS Evaluation Exercise initiated by Dr. Steve Running (University of Montana) in FY 2000. Our role in the exercise is to process half-hourly meteorological data (photosynthetically active radiation, relative humidity, air temperature, and precipitation) from ~15 AmeriFlux sites each week, post the processed data for ingest by two modeling groups (BIOME-BGC/University of Montana and LoTEC/ORNL), and post the resulting model output on the AmeriFlux WWW site for analysis and review (*http://cdiac.ornl.gov/programs/ameriflux/Analysis/Model_Evaluation/index.cfm*). During FY 2003, Tom Boden wrote an unsuccessful proposal to the NASA REASON solicitation seeking to improve the exercise by compiling detailed site characterizations for NASA-funded AmeriFlux sites participating in the exercise. At present the modeling groups are reliant on default ecosystem-level characterizations to represent many of the participating sites.

During the summer of 2003, AmeriFlux co-hosted an undergraduate computer science-major (Tim Racz, Appalachian State University) for the purpose of improving our WWW programming to address the issue of adhering to the AmeriFlux "fair-use" data policy and gaining better insight on users downloading AmeriFlux data. Tim created a Cold Fusion® interface to greet persons seeking to download data from the AmeriFlux WWW site with the "fair-use" agreement (*http://public.ornl.gov/ameriflux/Data/fair.cfm*). Once they accept the conditions of the fair-use agreement, the user is prompted to enter their name and e-mail address to enable us to notify them of future data updates and revisions. Once the user has submitted an e-mail address, Tim's program captures the e-mail address, generates a password randomly, sends the new password to the e-mail address furnished, and captures the name and e-mail address for cataloging. If the user tries to access the AmeriFlux data archive again they need only enter their name and password. Tim's programming efforts help us to promote proper use and acknowledgment of AmeriFlux data, offer better data services, and fully identify those retrieving AmeriFlux data.

The AmeriFlux Data Viewing and Retrieval System (*http://cdiac.ornl.gov/programs/ameriflux/data_system/aamer0.html*), introduced in FY 2002, was expanded to include additional AmeriFlux data and now offers data from 48 AmeriFlux sites. During FY 2003, approximately 450 users retrieved data using the system.

FY 2004 AmeriFlux Plans

Much is planned for FY 2004 to support the AmeriFlux data management activities at CDIAC. In early 2004, the AmeriFlux WWW site will be revamped to improve site navigation, better direct data users to the AmeriFlux network-wide database offered via the AmeriFlux Data Viewing and Retrieval System, generate downloadable maps, and offer more photos from AmeriFlux sites. Core AmeriFlux data activities remain a priority including processing data and making them available through the WWW interface. Efforts to automate and utilize limited resources more efficiently continue. For example, existing programs written to check the quality of incoming AmeriFlux data will be modified to improve automation and to produce

standardized reports identifying suspect values, which may be sent quickly to the data contributors. Efforts will continue to finalize the U* correction technique, developed by Lianhong Gu, and described above. Work will commence on the effort to assemble detailed site characterizations for AmeriFlux sites in the Upper Midwest Region beginning with extracting GIS coverages from existing ORNL coverages for eighteen individual sites. Efforts will continue to support network synthesis efforts including a new effort lead by Drs. HaPe Schmid, Gaby Katul, and Ram Oren attempting to quantify carbon budgets in eastern forest ecosystems.

2.2 Free-Air CO_2 Enrichment (FACE)

(*http://cdiac.ornl.gov/programs/FACE/face.html)*

CDIAC continued to develop its FACE Web site to support the global network of approximately 30 research sites that are operational, in development, or proposed. In FY 2003, CDIAC expanded its offerings of data from the ORNL FACE sweetgum stand. 1999-2002 data on leaf area index (LAI) were provided by Rich Norby, Johnna Sholtis, Carla Gunderson, and Sara Jawdy, and updates to the CO_2 and weather data were contributed by Jeffrey Riggs, Lynn Tharp, and Norby. In FY 2003, CDIAC also added 1998-2002 CO_2 data from the FACTS II (Rhinelander, Wisconsin) site, contributed by Jack Sober, Wendy Jones, and David Karnosky. Other FACE data previously available from CDIAC included plant dry weight data from the FACE pasture site in Bulls, New Zealand, contributed by Paul Newton and Harry Clark (Agresearch, Palmerston North, New Zealand).

FY 2004 FACE Plans

In FY 2004, we plan to add more variables to the FACE data for the ORNL site, as well as continue to update the LAI, CO_2, and weather files from that site. We also hope to add more data from the New Zealand and FACTS II sites and to include data from additional sites. As we do so, we expect to continue adding to our list of standardized variable names, definitions, and units.

2.3 NARSTO Quality Systems Science Center (QSSC)

(*http://cdiac.ornl.gov/programs/NARSTO/narsto.html*)

The tri-national (Canada, United States, and Mexico) NARSTO (originally North American Research Strategy for Tropospheric Ozone) program has broadened its objectives to include atmospheric pollutants besides ozone. NARSTO is a public/private partnership, open to science agencies, regulatory agencies, regulated industries, academic institutions, environmentalists, and public interest groups in North America. Its primary mission is to coordinate and enhance policy-relevant scientific research and assessment of tropospheric pollution behavior, with the central programmatic goal of determining workable, efficient, and effective strategies for local and regional air-pollution management.

In January 1997, DOE's Environmental Sciences Division began their sponsorship of the NARSTO Quality Systems Science Center (QSSC) within CDIAC. The QSSC reports to the NARSTO Executive Steering Committee through the NARSTO Management Coordinator and collaborates with the NARSTO science teams.

The QSSC works to ensure that relevant quality management systems are planned and implemented by

NARSTO technical programs. The NARSTO Quality Systems Management Plan (QSMP) *(http://cdiac.ornl.gov/programs/NARSTO/pdf/qsmp_current_version.PDF*) and the Quality Planning Handbook (QPHB) (*http://cdiac.ornl.gov/programs/NARSTO/pdf/qphb_current_version.PDF*), developed and maintained by the QSSC, provide the framework within which all quality-related activities are conducted.

The QSSC reviews project management and fieldwork planning documents and provides information to NARSTO partners seeking assistance with quality assurance, quality control, data management, and data archival.

The QSSC plans and coordinates NARSTO data management, data archival, and data dissemination activities. Timely sharing of, and ready access to, quality-assured NARSTO data and research products (e.g., computer models, methods, procedures, and reports) by the scientific community is essential to the success of the NARSTO program.

Data archive format specifications are implemented in the NARSTO Data Exchange Standard template. The QSSC performs a final quality assurance check of data sets submitted for archival, prepares archive documentation, and coordinates their transfer to the publicly available NARSTO permanent data archive (PDA) at the National Aeronautics and Space Administration (NASA) Langley Distributed Active Archive Center (DAAC). Data archived during 2003, including several Environmental Protection Agency (EPA) Particulate Matter Supersites data sets from Atlanta, Houston, Los Angeles, Fresno, and Pittsburgh, are available online at *http://eosweb.larc.nasa.gov/project/narsto/table_narsto.html*.

NARSTO quality systems and data management documents are available online at *http://cdiac.ornl.gov/programs/NARSTO/*. This Web site received approximately 400 visits per month.

In addition to these quality and data management activities, the QSSC continues to maintain the NARSTO Measurement Methods Compendium for ozone and particulate matter sampling and analysis technologies and methodologies. Method descriptions are available online at *http://cdiac.ornl.gov/programs/NARSTO/*.

QSSC staff expertise includes atmospheric chemistry, quality systems management, environmental data quality management, and data management coordination.

The FY 2003 QSSC's activities fall into three general areas: data management and archiving, data management support for projects, and external interactions.

Data Management and Archiving

During FY 2003, the following tasks were accomplished.

- Maintenance of data and metadata reporting standards.
- QSSC staff maintained standard value reference tables for chemical and physical variable names [e.g., over 900 chemical names and CAS (Chemical Abstracts Service) numbers; 50 chemical constituents without CAS numbers; and 150 variable names for physical measurements without CAS numbers]. Updates and enhancements were implemented in the Data Exchange Standard (DES) archive file format template and in the companion quality assurance Read and Verify Code.
- Maintenance of the NARSTO Data and Information Sharing Tool (DIST). DIST is a Web-based index and clearinghouse of atmospheric measurement, chemistry data, and metadata. Data are indexed using consistent metadata categories to support searching by project, location, date, keyword, and investigator. Data providers can use the Web-based DIST to conveniently enter metadata and to link their data and documents into the searchable DIST index. Atmospheric chemistry and meteorology data from the

Southern Oxidants Study (SOS) 1999 Atlanta Supersite Project and U.S. EPA PM Supersites Program data were made available to the public. An FTP site is associated with DIST for storage and retrieval of data sets. DIST is a key component in the flow of data from projects to the NARSTO PDA, with output capabilities that facilitate metadata and data archiving.

Data Management Support for Projects

The QSSC provides assistance to NARSTO research managers, principal investigators, and data managers. During FY 2003, the following tasks were accomplished.

- Interactions continued with the Mexico City Metropolitan Area Program, sponsored by the Massachusetts Institute of Technology. We provided guidance on reporting of date and time by field teams and consulted on questions regarding implementation of NARSTO standard values.
- The QSSC continued data management support to the U.S. Environmental Protection Agency (EPA) Particulate Matter (PM) Supersites Program. In consultation with EPA and the data coordinators of the Supersite projects, the QSSC, with the financial support of EPA, is coordinating the following activities:

  a. Support for maintenance of a consistent set of metadata for the Supersites measurement data. Metadata are the data that describe, for measured results, the important details as to: what, where, when, how, why, and by whom. Periodic teleconference discussions keep the process moving. The Supersites Program provides quality-assured data to the QSSC for archiving in accordance with the published NARSTO guidelines.
  b. Maintenance of the NARSTO DIST for the Supersites Program to support sharing of data among investigators and to use DIST's output capabilities to facilitate data archiving. The addition of new features and modifications to metadata will be made as necessary for effective implementation. The addition of new DIST users, system administration, and user support is included in this activity.
  c. Maintenance of the Supersites FTP Site to support the submission of Supersites Program data to the QSSC. Supersite project data coordinators may add and maintain data on the FTP site to allow program-wide access to data, while not permitting access to secure project systems.
  d. Archiving of numerous Supersites data sets to the NARSTO PDA (e.g., Atlanta's "1999 Air Chemistry, Particulate Matter, and Met Data", Houston's "Differential Mobility Analyzer Data", Pittsburgh's "Rapid Single-Particle Mass Spectrometer Data" and Los Angeles's "TEOM PM2.5 Mass Concentration Data").

External Interactions

Bill Sukloff (Environment Canada, Meteorological Service of Canada) visited the QSSC in May 2003. This was Bill's fifth working visit to Oak Ridge. During his visit, QSSC staff worked with Bill on the continued development and updating of the Data Exchange Standard archive data format Read and Verify Program and accompanying reference tables. Bill is the data coordinator for several Canadian air quality monitoring networks and NARSTO-affiliated intensive air quality investigations.

These various coordinated efforts, to address NARSTO data management activities in a coordinated and efficient manner, encourage sharing of the considerable technical, measurement, and data management knowledge and system resources that already exist across the Supersites projects, NARSTO, EPA, and externally. Staff from other NARSTO, EPA, and similar atmospheric research projects are encouraged to take advantage of these results and contribute their experience and data. This coordinated effort, envisioned as a model for future cooperation, is a prime example of why NARSTO was formed and how it can function.

Meetings Attended

- Les Hook, Director, attended the Annual Executive Assembly/Steering Committee Meeting, Washington, D.C., March 2003.

- Les Hook and Sig Christensen presented posters about NARSTO's tropospheric ozone and particulate matter research and distributed CDs of the new NARSTO assessment, "Particulate Matter Science for Policy Makers" (*http://cdiac.ornl.gov/programs/NARSTO/*) at the Regional Clean Air Action Summit (Knoxville, Tennessee), April 2003.

2.4 Ocean Data

(*http://cdiac.ornl.gov/oceans/home.html*)

The World Ocean Circulation Experiment (WOCE) Hydrographic Program (WHP) is a major component of the World Climate Research Program with the overall goal of better understanding the ocean's role in climate and climatic changes resulting from both natural and anthropogenic causes. The levels of CO_2 in the oceans are unevenly distributed because of complex circulation patterns and biogeochemical cycles. Although CO_2 is not an official WOCE measurement, a coordinated effort, supported in the United States by DOE, was made on WOCE cruises through 1998 to measure the global-scale and temporal distributions of total carbon dioxide (TCO_2) and related parameters.

Goals of the survey were to estimate the meridional transport of inorganic carbon in a manner analogous to the estimation of the transport of oceanic heat and to build a database suitable for inclusion in carbon cycle modeling and the estimation of anthropogenic CO_2 increase in the oceans. The CO_2 survey took advantage of the sampling opportunities provided by the WHP cruises during this period. The final data set is expected to cover approximately 23,000 stations from 42 WOCE cruises.

CDIAC provides data management support for the Joint Global Ocean Flux Study (JGOFS) CO_2 measurements taken aboard research vessels during WHP cruises. DOE has sponsored CO_2 measurement operations and continues to sponsor CDIAC's data support activities, which include data archival, data checking and evaluation, data documentation, and data dissemination. All CO_2-related data are checked before documentation and distribution. Through the end of FY 2003, DOE-supported investigators had collected CO_2 measurements on 42 WOCE cruises. CDIAC has received data from all of these cruises, and these data sets have undergone quality assurance checks; 21 are fully documented as numeric data products (NDPs). CDIAC also received carbon-related data from six international WOCE cruises. The WOCE carbon and hydrographic data are available through the Internet in three different formats: as a WOCE ASCII data format, CSV format, and an Ocean Data View (ODV) Collection.

CDIAC provides data management support for the GLobal Ocean Data Analysis Project (GLODAP). GLODAP is a cooperative effort of investigators funded for synthesis and modeling projects through the National Oceanic and Atmospheric Administration (NOAA), DOE, and the National Science Foundation (NSF). Cruises conducted as part of the WOCE, JGOFS, and the NOAA Ocean-Atmosphere Carbon Exchange Study (OACES) during the 1990s have generated oceanographic data of unparalleled quality and quantity.

Most of the data have been reported to national archive facilities but have not been integrated into an internally consistent global data set. GLODAP will compile that data set and examine the global distribution and inventories of oxygen, nutrients, natural and anthropogenic carbon species, natural and bomb-produced radiocarbon (^{14}C), and ^{13}C. These estimates will be used to infer nutrient remineralization ratios (Redfield ratios) and the rate of anthropogenic CO_2, ^{13}C, and bomb ^{14}C uptake in the oceans. These estimates provide an important benchmark for comparison with future observational studies. They also provide tools for the direct evaluation of numerical models of the transport and fate of carbon in the oceans. CDIAC has opened a new Web page for the final GLODAP products (*http://cdiac.ornl.gov/oceans/GLODAP/Glodap_home.htm*). CDIAC has developed a GLODAP Electronic Atlas for carbon measurements. The high-quality figures for carbon section profiles are available in JPG and EPS formats through clickable maps. The GLODAP data are available through Live Access Server (LAS) which was implemented by CDIAC in 2003. The LAS distributes both bottle and gridded GLODAP data through its server. The GLODAP bottle data are also available as CSV files for each ocean as well as an ODV collection.

CDIAC provides data management support for the project CARINA (CARbon dioxide IN the Atlantic ocean). The CARINA objectives are:

- to bring together research groups that measure CO_2 in the North Atlantic Ocean;
- to create an inventory of CO_2 measurements carried out in the North Atlantic Ocean;
- to make available unpublished data to the data contributors (data access); to form working groups that cooperate on various aspects of the CO_2 system in the North Atlantic; and
- to exchange information concerning CO_2 research in the North Atlantic.

In 2003 Alex Kozyr was one of the organizers of the Second International CARINA Science Meeting in Maspalomas, Gran Canaria, Spain.

CDIAC also plays a major role in the CO_2 data management for the North Pacific Marine Science Organization (PICES) Working Group 17 (WG17). The main goal of the WG17 is to work with the Japan Oceanographic Data Center (JODC), National Oceanographic Data Center (NODC), CDIAC, Marine Environmental Data Service (MEDS), et al. to complete an International North Pacific data set for CO_2 and CO_2-related parameters TCO_2, total alkalinity (TALK), partial pressure of carbon dioxide (pCO_2), etc. Another goal is to encourage PICES countries (Japan, South Korea, China, Canada, Russia, and the United States) and non-PICES countries to contribute data and information on data to the PICES data inventory.

In 2003 CDIAC's Alex Kozyr became a member of the Surface Ocean - Lower Atmosphere Study (SOLAS) Implementation Group 3 (IMP-3). The IMP-3 has a mandate to implement and co-ordinate Focus 3 of SOLAS which is Air-Sea Flux of CO_2 and other long-lived radiatively-active gases.

Meetings Attended

- PICES XI Annual Meeting and WG-17 Meeting, Qingdao, People's Republic of China, October 18 ! 26, 2002.
- Global Carbon Project International Ocean Carbon Coordination Workshop organized by SCOR-IOC Advisory Panel on Ocean CO_2 and the IGBP-IHDP-WCRP, Paris, January 13 ! 15, 2003.
- Second International CARINA Science Meeting in Maspalomas, Gran Canaria, Spain, Feb. 26 ! Mar. 1, 2003.

- North America Carbon Program Meeting, Washington, DC, May, 2003.

3. Data and Information Products

CDIAC's carbon dioxide-related products provide data and information in several areas relevant to the greenhouse effect and global climate change. These areas include records of atmospheric trace gases [CO_2, methane, nitrous oxide, chlorofluorocarbons (CFCs), and aerosols], global carbon cycle parameters, long-term climate records, coastal vulnerability to rising sea level, demographics, land use and ecosystems, oceanic trace gases, solar and atmospheric radiation, trace gas emissions, and vegetation response to CO_2 and climate changes.

CDIAC compiles and distributes holdings in the form of data products [e.g., numeric data packages (NDPs), databases (DBs), and computer model packages (CMPs)] and printed publications. All products are provided free of charge. Data files and documentation (text, PDF, or HTML version), which accompany the data products, may be accessed and downloaded from CDIAC's Web site (*http://cdiac.ornl.gov/*), from CDIAC's anonymous FTP area (*ftp://cdiac.ornl.gov*), or requested directly from CDIAC on various types of media (e.g., CD-ROM, floppy diskette). Printed reports are available from CDIAC on request. All technical questions (e.g., methodology or accuracy) should be directed to the CDIAC staff member responsible for preparing the particular data product.

3.1 New Data Products (arranged by date of release during FY 2003)

- **Carbon Dioxide, Hydrographic and Chemical Data Obtained During the Nine R/V *Knorr* Cruises Comprising the Indian Ocean CO_2 Survey (WOCE Sections I8SI9S, I9N, I8NI5E, I3, I5WI4, I7N, I1, I10, and I2; December 1, 1994 - January 22, 1996)** (ORNL/CDIAC-138, NDP-080)
  http://cdiac.ornl.gov/oceans/ndp_080/ndp080.html

  Contributors: Kenneth M. Johnson (Brookhaven National Laboratory), Andrew G. Dickson (Scripps Institution of Oceanography) , Greg Eischeid (Woods Hole Oceanographic Institute), Catherine Goyet (University of Perpignan, France), Peter R. Guenther (Scripps Institution of Oceanography), Robert M. Key (Princeton University), Kitack Lee (University of Miami), Ernest R. Lewis (Brookhaven National Laboratory), Frank J. Millero (University of Miami), David Purkerson (University of Miami), Christopher L. Sabine (Pacific Marine Environmental Laboratory), Rolf G. Schottle (University of Hawaii), Douglas W. R. Wallace (Institut fur Meereskunde, Universitat Kiel), Richard J. Wilke (Brookhaven National Laboratory), and Christopher D. Winn (Hawaii Pacific University).

  Prepared by Alex Kozyr, CDIAC; October 2002.

  This document describes the procedures and methods used to measure total carbon dioxide (TCO_2) and total alkalinity (TALK) at hydrographic stations taken during the R/V Knorr Indian Ocean cruises (Sections I8SI9S, I9N, I8NI5E, I3, I5WI4, I7N, I1, I10, and I2) in 1994 ! 1996. The measurements were conducted as part of the World Ocean Circulation Experiment (WOCE). The expedition began in Fremantle, Australia, on December 1, 1994, and ended in Mombasa, Kenya, on January 22, 1996. During the nine cruises, 12 WOCE sections were occupied.

  Total carbon dioxide was extracted from water samples and measured using single-operator multiparameter metabolic analyzers (SOMMAs) coupled to coulometers. The overall precision and

accuracy of the analyses was ±1.20 µmol/kg. The second carbonate system parameter, TALK, was determined by potentiometric titration. The precision of the measurements determined from 962 analyses of certified reference material was ±4.2 µmol/kg (REFERENCE). This work was supported by grants from the National Science Foundation, the U. S. Department of Energy, and the National Oceanographic and Atmospheric Administration.

- **Cloud Climatology for Land Stations Worldwide, 1971 ! 1996**, (NDP-026D)
  http://cdiac.ornl.gov/epubs/ndp/ndp026d/ndp026d.html

  Contributors: Carole Hahn (University of Arizona) and Stephen Warren (University of Washington).

  Prepared by: Dale Kaiser, CDIAC; March 2003.

  Surface synoptic weather reports for 26 years were processed to provide a climatology of clouds for each of over 5000 land-based weather stations. For each station, this digital archive includes multi-year annual, seasonal and monthly averages for day and night separately; seasonal and monthly averages by year; averages for eight times per day; and analyses of the first harmonic for the annual and diurnal cycles. Averages are given for total cloud cover, clear-sky frequency, and nine cloud types. Cloud amounts and frequencies of occurrence are given for all types. In addition, non-overlapped amounts are given for middle and high cloud types, and average base heights are given for low cloud types. Nighttime averages were obtained by using only those reports that met an "illuminance criterion" (i.e., made under adequate moonlight or twilight), thus making possible the determination of diurnal cycles and nighttime trends for cloud types.

- **CSIRO GASLAB Network Individual Flask Measurements of Atmospheric Trace Gases** (DB1021)
  http://cdiac.ornl.gov/epubs/db/db1021/db1021.html

  Contributors: Paul Steele, Paul Krummel, and Ray Langenfelds (Commonwealth Scientific and Industrial Research Organisation, Australia)

  Prepared by T.J. Blasing and Sonja Jones, CDIAC; April 2003.

  Data are available for four atmospheric trace gases at nine stationary sites and one moving platform (aircraft over Cape Grim, Tasmania; and Bass Strait, between the Australian continent and Tasmania). The trace gases are carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), and hydrogen (H_2). The nine stationary sites are, from north to south: Alert, Canada; Shetland Islands, Scotland; Estevan Point, Canada; Mauna Loa, Hawaii; Cape Ferguson, Australia; Cape Grim; Macquarie Island, Australia; Mawson, Antarctica; and the South Pole station, Antarctica. The earliest data are from April 1984 (period of record varies by gas and station) and the data extend through September 2000 (aircraft data) or December 2001 (stationary sites).

- **Measurements of CH_4 mixing ratio and D/H and $^{13}C/^{12}C$ isotope ratios in atmospheric samples from two sites in the United States** (DB1022) *http://cdiac.ornl.gov/epubs/db/db1022/db1022.html*

Contributor: Stanley Tyler (University of California Irvine)

Prepared by T.J. Blasing and Sonja Jones, CDIAC; May 2003 and July 2003.

This database contains atmospheric methane concentrations and associated D (deuterium, a hydrogen isotope) and ^{13}C measurements from air samples collected at approximately bi-weekly intervals from two fixed surface sites in the United States. These sites are Niwot Ridge, Colorado, a mid-continental site (41N 105W); and Montana de Oro, California (35N 121W), a Pacific Coast site receiving strong westerlies. The continuous record of CH_4 mixing ratio and ^{13}C-CH_4 from Niwot Ridge extends from 1995 to 1998, while that of Montana de Oro extends from 1996 to 1998. Such time series can provide(1) information relating seasonal cycling of CH_4 sources and sinks in background air, (2) a record of long-term trends in CH_4 mixing and isotope ratio related to the atmospheric CH_4 loading, and, possibly, (3) an indication of regional CH_4 sources.

- **Interannual Variability in Global Soil Respiration on a 0.5 Degree Grid Cell Basis** (NDP-081, formerly DB1015) *http://cdiac.ornl.gov/epubs/ndp/ndp081/ndp081.html*.

  Contributors: James Raich (Iowa State University), Christopher Potter (NASA Ames Research Center), and Dwipen Bhagawati (Iowa State University)

  Prepared by: Lisa Olsen, CDIAC; August 2003.

  A climate-driven regression model was used to develop spatially-resolved estimates, based on new climate and land-cover data files, of soil-CO_2 emissions from the terrestrial land surface for each month from January 1980 to December 1994, to evaluate the effects of interannual variations in climate on global soil-to-atmosphere CO_2 fluxes. The mean annual global soil-CO_2 flux over this 15-yr period was estimated to be 80.4 (range 79.3-81.8) Pg C. Monthly variations in global soil-CO_2 emissions followed closely the mean temperature cycle of the Northern Hemisphere. Globally, soil-CO_2 emissions reached their minima in February and peaked in July and August. Tropical and subtropical evergreen broad-leaved forests contributed more soil-derived CO_2 to the atmosphere than did any other vegetation type (~30% of the total) and exhibited a biannual cycle in their emissions.

- **Comparison of Inorganic Carbon System Parameters Measured in the Atlantic Ocean from 1990 to 1998 and Recommended Adjustments** (CDIAC-140)
  http://cdiac.ornl.gov/oceans/aoml/cdiac_140.html

  Contributors: Rik Wanninkhof, Tsung-Hung Peng, and Betty Huss (Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida), Christopher L. Sabine (Pacific Marine Environmental Laboratory, Seattle, Washington), and Kitack Lee (Pohang University of Science and Technology, Republic of Korea)

  Prepared by Alex Kozyr, CDIAC; September 2003.

  A comprehensive comparison was performed of inorganic carbon parameters measured on oceanographic surveys carried out under auspices of the Joint Global Ocean Flux Study and related programs. Many of

the cruises were performed as part of the World Hydrographic Program of the World Ocean Circulation Experiment and the NOAA Ocean-Atmosphere Carbon Exchange Study. Total dissolved inorganic carbon (DIC), total alkalinity (TAlk), fugacity of CO_2, and pH data from twenty-three cruises were checked to determine whether there were systematic offsets of these parameters between cruises. The focus was on the DIC and TAlk state variables. Data quality and offsets of DIC and TAlk were determined by using several different techniques. For several of the cruises, small adjustments in TAlk were recommended for consistency with other cruises in the region. After these adjustments were incorporated, the inorganic carbon data from all cruises along with hydrographic, chlorofluorocarbon, and nutrient data were combined as a research-quality product for the scientific community.

- **Carbon Dioxide, Hydrographic, and Chemical Data Obtained During the R/V *Knorr* Cruises in the North Atlantic Ocean on WOCE Sections AR24 (November 2 - December 5, 1996) and A24, A20, and A22 (May 30 - September 3, 1997)** (ORNL/CDIAC-143, NDP-082)
  http://cdiac.ornl.gov/oceans/ndp_082/ndp082.html

  Contributers: Kenneth M. Johnson (Brookhaven National Laboratory), Robert M. Key (Princeton University), Frank J. Millero (University of Miami), Christopher L. Sabine (Pacific Marine Environmental Laboratory), Douglas W. R. Wallace (Institut fur Meereskunde, Universitat Kiel), Christopher D. Winn (Hawaii Pacific University), L. Arlen (James J. Howard Laboratory), K. Erickson (Brookhaven National Laboratory), K. Friis (Institute for Marine Sciences, Kiel, Germany), M. Galanter, (University of Miami), J. Goen (University of Miami), R. Rotter (Princeton University), C. Thomas (Princeton University), R. Wilke (Lamont-Doherty Earth Observatory), T. Takahashi (Lamont-Doherty Earth Observatory), and S. Sutherland (Lamont-Doherty Earth Observatory).

  Prepared by Alex Kozyr, CDIAC; September 2003.

  This documentation describes the procedures and methods used to measure total carbon dioxide (TCO_2) total alkalinity (TALK), and partial pressure of CO_2 (pCO_2) at hydrographic stations on the North Atlantic Ocean sections AR24, A24, A20, and A22 taken during the R/V *Knorr* Cruises 147-2, 151-2, 151-3, and 151-4 in 1996 and 1997. Conducted as part of the World Ocean Circulation Experiment (WOCE), the expeditions began at Woods Hole, Massachusetts, on October 24, 1996, and ended at Woods Hole on September 3, 1997.

  A total of 5,614 water samples were analyzed for discrete TCO_2 using two single-operator multiparameter metabolic analyzers (SOMMAs) coupled to a coulometer for extracting and detecting CO_2. The overall accuracy of the TCO_2 determination was ± 1.59 µmol/kg. The TALK was determined in a total of 6,088 discrete samples on all sections by potentiometric titration using an automated titration system developed at the University of Miami. The accuracy of the TALK determination was ± 3µmol/kg. A total of 2,465 discrete water samples were collected for determination of pCO_2 in sea water on sections A24, A20, and A22. The pCO_2 was measured by means of an equilibrator-IR system by scientists from Lamont-Doherty Earth Observatory. The precision of the measurements was estimated to be about ± 0.15%, based on the reproducibility of the replicate equilibrations on a single hydrographic station.

- **Carbon Sequestration CSiTE** *http://csite.esd.ornl.gov/*

  Prepared by: Bob Cushman, Lynn Kszos, and Tris West, CDIAC; 2003.

During FY 2003, in collaboration with the DOE Consortium for Enhancing Carbon Sequestration in Terrestrial Ecosystems, CDIAC began to document and offer online several data sets concerning terrestrial carbon sequestration. The following data sets were posted during FY 2003.

- Grassland Management and Conversion into Grassland: Effects on Soil Carbon (Conant et al., Colorado State University)
- Changes in Soil Carbon Following Afforestation (Paul et al., Commonwealth Scientific and Industrial Research Organisation, Australia)
- Potential for Carbon Sequestration in European Soils: Preliminary Estimates for Five Scenarios Using Results from Long-Term Experiments (Smith et al., University of Aberdeen, United Kingdom)
- Preliminary Estimates of the Potential for Carbon Mitigation in European Soils Through No-Till Farming (Smith et al., University of Aberdeen, United Kingdom)
- Soil Carbon Sequestration by Tillage and Crop Rotation: A Global Data Analysis (West and Post, Oak Ridge National Laboratory)

3.2 Updated Data Products

- **CSIRO GASLAB Network: Individual Flask Measurements of Atmospheric Trace Gases** (DB1021) *http://cdiac.ornl.gov/epubs/db/db1021/db1021.html*

  Contributors: C. E. Allison, R. J. Francey and P. B. Krummel (Commonwealth Scientific and Industrial Research Organization), Australia

  Updated by T.J. Blasing and Sonja Jones, CDIAC; May 2003.

  Measurements of the ^{13}C isotopic fraction of CO_2 sampled at nine stations in the CSIRO GASLAB Flask Sampling Network have now been added to CDIAC DB1021. Sampling locations are Alert, Canada; Cape Ferguson, Australia; Cape Grim, Australia; Estevan Point, Canada; Mawson, Antarctica; Mauna Loa, Hawaii; Macquarie Island, Australia; Shetland Islands, Scotland; and the South Pole, Antarctica. The period of record begins sometime during 1990 at all but two stations: Estevan Point (1993) and Shetland Islands (1992). The data are current through 2001 except for the South Pole station; analysis for the South Pole takes longer than for less remote sites. The downward trend in C-13 isotopic fraction, reflecting the increase in fossil-fuel derived CO_2 in the atmosphere, is evident at all stations.

- **Atmospheric CO_2 Concentrations ! Mauna Loa Observatory, Hawaii, 1958 ! 2002 (NDP-001)** *http://cdiac.ornl.gov/ndps/ndp001.html*

  Contributors: C. D. Keeling and T. P. Whorf (Scripps Institution of Oceanography, University of California)

  Updated by Tom Boden, CDIAC; June 2003.

  Since 1958, air samples have been continuously collected at Mauna Loa Observatory and analyzed by infrared spectroscopy for CO_2 concentrations. Data are averaged to give monthly and annual atmospheric CO_2 concentrations.

  These data represent the longest continuous record of atmospheric CO_2 concentrations in the world. This precise data record covers a single site (Mauna Loa Observatory, Hawaii). It is a reliable indicator of

the regional trend in the concentration of atmospheric CO_2 in the middle layers of the troposphere and is critical to CO_2-related research.

- **The ALE/GAGE/AGAGE Network (DB1001)**
  http://cdiac.ornl.gov/ndps/alegage.html

  Contributors: R. Prinn (Massachusetts Institute of Technology); D. Cunnold, and R. H. J. Wang (Georgia Institute of Technology); P. Fraser and L. P. Steele (Commonwealth Scientific and Industrial Research Organisation); R. Weiss and P. Salamen (Scripps Institution of Oceanography); P. Simmonds (Bristol University, United Kingdom)

  Updated by T. J. Blasing and Sonja Jones, CDIAC; July 2003.

  CDIAC has released the updated data base from the global ALE/GAGE/AGAGE monitoring network, which provides continuous high-frequency measurements of methane, nitrous oxide, several halogenated hydrocarbons, carbon monoxide, and hydrogen. This data base supports analyses and monitoring related to greenhouse gases and to the Earth's ozone layer. Data through September 2002 are now available for all five existing sites: Cape Grim, Tasmania; Point Matatula, American Samoa; Ragged Point, Barbados; Mace Head, Ireland; and Trinidad Head, California (stations also previously existed at Cape Meares, Oregon, and Adrigole, Ireland).

- **Annual and Seasonal Global Temperature Deviations in the Troposphere and Low Stratosphere, 1958-2002**
  http://cdiac.ornl.gov/ndps/ndp008.html

  Contributed by: J. K. Angell (NOAA Air Resources Laboratory)

  Updated by Sonja Jones and Dale Kaiser, CDIAC; August 2003.

  Surface temperatures and thickness-derived temperatures from a 63-station, globally distributed radiosonde network have been used to estimate global, hemispheric, and zonal annual and seasonal temperature deviations from 1958 through 2002. Most of the temperature values used were column-mean temperatures, obtained from the differences in height (thickness) between constant-pressure surfaces at individual radiosonde stations. The pressure-height data before 1980 were obtained from published values in Monthly Climatic Data for the World. Between 1980 and 1990, Angell used data from both the Climatic Data for the World and the Global Telecommunications System (GTS) Network received at the National Center for Atmospheric Research files. The data are evaluated as deviations from the mean based on the interval 1958 ! 1977 and pertain to the surface and the following atmospheric layers: troposphere (850 ! 300 mb), tropopause (300 ! 100 mb), low stratosphere (100 ! 50 and 100 ! 30 mb), and from the surface up to 100 mb. Individual data sets containing the above measurements are provided for the globe, the Northern and Southern Hemispheres, and the following latitudinal zones: North Polar (60 ! 90 N) and South Polar (60 ! 90 S); North Temperate (30 ! 60 N) and South Temperate (30 ! 60 S); North Subtropical (10 ! 30 N) and South Subtropical (10 ! 30 S); Tropical (30 N ! 30 S); and Equatorial (10 N ! 10 S).

- **Current Greenhouse Gas Concentrations** T. J. Blasing and Sonja Jones (Oak Ridge National Laboratory) *http://cdiac.ornl.gov/pns/current_ghg.html*

  Updated by T. J. Blasing and Sonja Jones, CDIAC; September 2003.

This summary table offers current and pre-1750 concentrations, atmospheric lifetimes, and the contribution of each trace gas to global warming as published by the Intergovernmental Panel on Climate Change (IPCC), CDIAC, and selected other sources (links to data sources are provided). This Web table includes much tutorial material and many references to the latest IPCC assessment reports.

3.3 Trends Online

- **Area and Carbon Content of Sphagnum Since Last Glacial Maximum**
  http://cdiac.ornl.gov/trends/ecosystems/ecosystems.html

  Contributors: K. Gajewski, A. Viau, M. Sawada, D. Atkinson and S. Wilson (University of Ottawa)

  Prepared by Tris West and Lynn Kzsos, CDIAC; October 2002.

  This is the first data set in a new Trends Online "Ecosystems" section. The data were contributed by K. Gajewski, A. Viau, M. Sawada, D. Atkinson and S. Wilson (Laboratory for Paleoclimatology and Climatology, Department of Geography, University of Ottawa) and put online by Bob Cushman. Area (estimated separately for North America, Europe, and Asia) and total carbon content (low, high, and mean vales) are estimated, at 2000-year intervals, from the distribution and abundance of Sphagnum spores in North America and Eurasia over the past 21 ka (21,000 years). Carbon accumulation in peatlands is estimated to be low prior to 11 ka BP (before present), increased slightly between 11 and 5 ka BP, and greatly increased during the past 5 ka BP.

- **Carbon Flux to the Atmosphere from Land-Use Changes**
  http://cdiac.esd.ornl.gov/trends/landuse/houghton/houghton.html

  Contributors: Richard A. Houghton and Joseph L. Hackler (The Woods Hole Research Center)

  Prepared by Bob Cushman, CDIAC; October 2002.

  CDIAC has updated this database record with estimates from 1850 through 2000. This dataset provides annual estimates of net fluxes caused by deliberate changes in land use (e.g., clearing of forests for agriculture, harvest of wood for fuel or timber) in nine regions of the world. The estimated global total net flux of carbon from changes in land use increased from 0.5 Pg C (1 petagram = 10^{15} or 1,000,000,000,000,000 grams) in 1850 to a maximum of 2.4 Pg C in 1991, then declined to 2.1 Pg C in 2000. The global net flux during the period 1850-2000 was 156 Pg C, about 63% of which was from the tropics. During this period, the greatest regional flux was from Tropical Asia (48 Pg C), while the smallest regional flux was from North Africa and Middle East (3 Pg C). The global total flux averaged 2.0 Pg C/yr during the 1980s and 2.2 Pg C/yr during the 1990s (but generally declining during that latter decade), dominated by fluxes from tropical deforestation. For the U.S., the estimated flux is a net source to the atmosphere of 7 Pg C for the period 1850 ! 2000, but a net sink of 1.2 Pg C for the 1980s and 1.1 Pg C for the 1990s.

- **Atmospheric CO_2 Concentrations from the CSIRO GASLAB Flask Sampling Network**
  http://cdiac.ornl.gov/trends/co2/csiro/csiro_gaslab.html

Contributors: L.P. Steele, P.B. Krummel and R.L. Langenfelds (Commonwealth Scientific and Industrial Research Organisation, Australia)

Prepared by T.J. Blasing and Sonja Jones, CDIAC; December 2002.

Individual measurements were obtained from flask air samples returned to the CSIRO GASLAB from nine globally distributed stations (Alert, Northwest Territories, Canada; Cape Ferguson, Australia; Cape Grim, Australia; Estevan Point, British Columbia, Canada; Macquarie Island, Australia; Mauna Loa, Hawaii, USA; Mawson, Antarctica; Shetland Islands, Scotland; and South Pole, Antarctica). The period of record begins as early as December 1990 (varies by station) and continues through December 2001. Average annual increases in concentration since the early 1990s range from 1.5 ppmv/yr (parts per million by volume per year) (Mawson) to 1.8 ppmv/yr (Estevan Point).

- **Atmospheric CH_4 Concentrations from the CSIRO GASLAB Flask Sampling Network**
  http://cdiac.ornl.gov/trends/atm_meth/csiro/csiro_gaslabch4.html

  Contributors: L.P. Steele, P.B. Krummel and R.L. Langenfelds (Commonwealth Scientific and Industrial Research Organisation, Australia)

  Prepared by T.J. Blasing and Sonja Jones, CDIAC; January 2003.

  Individual measurements were obtained from flask air samples returned to the CSIRO GASLAB from nine globally distributed stations (Alert, Northwest Territories, Canada; Cape Ferguson, Australia; Cape Grim, Australia; Estevan Point, British Columbia, Canada; Macquarie Island, Australia; Mauna Loa, Hawaii, USA; Mawson, Antarctica; Shetland Islands, Scotland; and South Pole, Antarctica). The period of record varies by station, beginning as early as 1984 and continuing as late as December 2001. The average annual concentration of methane increased by more than 10 ppbv (parts per billion by volume) per year during the 1980s, about +5 ppbv/year during the 1990s, and has leveled off to an almost constant rate over the last three years. These methane data complement the carbon dioxide data from the same CSIRO sampling network announced previously (*http://cdiac.ornl.gov/trends/co2/csiro/csiro_gaslab.html*).

- **Kyoto-Related Fossil-Fuel CO_2 Emission Totals**
  http://cdiac.ornl.gov/trends/emis/annex.htm

  Contributors: Gregg Marland and Tom Boden (CDIAC)

  Prepared by Tom Boden, CDIAC; January 2003.

  This table shows the total release of CO_2 from fossil-fuel use and cement manufacture for those countries listed in Annex B of the Kyoto Protocol and for those countries not listed in Annex B. Emissions from international bunker fuels (fuels used in international commerce) are not included in the country totals but are shown separately under the country group in which final fuel loading occurred.

- **Atmospheric CO Concentrations from the CSIRO GASLAB Flask Sampling Network**
  http://cdiac.ornl.gov/trends/otheratg/csiro-co/csiro_gaslabco.html

  Contributors: L.P. Steele, P.B. Krummel and R.L. Langenfelds (Commonwealth Scientific and Industrial Research Organisation, Australia)

Prepared by T.J. Blasing and Sonja Jones, CDIAC; February 2003.

Individual measurements were obtained from flask air samples returned to the CSIRO GASLAB from nine globally distributed stations (Alert, Northwest Territories, Canada; Cape Ferguson, Australia; Cape Grim, Australia; Estevan Point, British Columbia, Canada; Macquarie Island, Australia; Mauna Loa, Hawaii, USA; Mawson, Antarctica; Shetland Islands, Scotland; and South Pole, Antarctica). The period of record begins as early as May 1984 (varies by station) and continues through December 2001. Long-term trends are not evident in these data. However, peak concentrations were observed on a global scale in 1998; these may be related to unusually large amounts of biomass burning in southeast Asia (especially Indonesia) and also in South America.

- **Historical carbon dioxide record from the Vostok ice core**
  http://cdiac.ornl.gov/trends/co2/vostok.htm

  Contributors: J.-M. Barnola, D. Raynaud, and C. Lorius. (Laboratoire de Glaciologie et de Géophysique de l'Environnement, Saint Martin d'Heres Cedex, France) and N.I. Barkov (Arctic and Antarctic Research Institute, St. Petersburg, Russia)

  Prepared by T.J. Blasing and Sonja Jones, CDIAC; February 2003.

  The new data extend the record back in time by about 3000 years, so the period of record is now 417,160 - 2,342 years before present. In January 1998, the collaborative ice-drilling project between Russia, the United States, and France at the Russian Vostok station in East Antarctica yielded the deepest ice core ever recovered, reaching a depth of 3,623 m. Ice cores are unique with their long records of entrapped air inclusions, enabling direct records of past changes in atmospheric trace-gas composition. Preliminary data indicate the Vostok ice-core record extends through four climate cycles, with ice slightly older than 400 kyr. There is a close correlation between Antarctic temperature and atmospheric concentrations of CO_2. The extension of the Vostok CO_2 record shows that the main trends of CO_2 are similar for each glacial cycle. Major transitions from the lowest to the highest values are associated with glacial-interglacial transitions. During these transitions, the atmospheric concentrations of CO_2 rose from 180 to 280 ! 300 ppmv. At the beginning of deglaciations the CO_2 increase was approximately in phase with Antarctic temperature, whereas it clearly lagged behind the temperature after the onset of deglaciation.

- **Atmospheric H_2 Concentrations from the CSIRO GASLAB Flask Sampling Network**
  http://cdiac.ornl.gov/trends/otheratg/csiro-h2/contents.html

  Contributors: L.P. Steele, P.B. Krummel and R.L. Langenfelds (Commonwealth Scientific and Industrial Research Organisation, Australia)

  Prepared by T.J. Blasing and Sonja Jones, CDIAC; March 2003.

  Individual measurements were obtained from flask air samples returned to the CSIRO GASLAB from nine globally distributed stations (Alert, Northwest Territories, Canada; Cape Ferguson, Australia; Cape

Grim, Australia; Estevan Point, British Columbia, Canada; Macquarie Island, Australia; Mauna Loa, Hawaii, USA; Mawson, Antarctica; Shetland Islands, Scotland; and South Pole, Antarctica). The period of record for most stations begins in 1992 and continues through December 2001. Long-term trends are not evident in these data. However, globally averaged peak concentrations were observed on a global scale in 1998; these may be related to unusually large amounts of biomass burning in southeast Asia, especially Indonesia, and also in South America.

- **Estimates of Monthly CO_2 Emissions and Associated $^{13}C/^{12}C$ Values from Fossil-Fuel Consumption in the U.S.A.** *http://cdiac.ornl.gov/trends/emis_mon/emis_mon_co2.html*

  Contributors: T.J. Blasing (CDIAC), Christine Broniak (Penn State summer student), and Gregg Marland (CDIAC).

  Prepared by Sonja Jones, CDIAC; June 2003.

  Data are available for the years 1981 ! 2002. These estimates were derived from values of fuel consumed, multiplied by their respective thermal conversion factors, and then multiplied by their respective carbon dioxide emission factors. An annual cycle, peaking during the winter months and reflecting natural gas consumption, and a semi-annual cycle of lesser amplitude, peaking in summer and winter and reflecting coal consumption, comprise the dominant features of the annual pattern. There were relatively constant emissions until 1987, followed by an increase from 1987 ! 1989, a decrease in 1990 ! 1991, and record highs during the late 1990s; emissions have declined somewhat since 2000.

- **Monthly surface air temperature time series area-averaged over the 30-degree latitudinal belts of the globe** *http://cdiac.ornl.gov/trends/temp/lugina/lugina.html*

  Contributors: K.M. Lugina (St. Petersburg State University, Russia), P.Ya. Groisman (National Climatic Data Center, Asheville, North Carolina), K.Ya. Vinnikov (University of Maryland), and V.V. Koknaeva and N.A. Speranskaya (State Hydrological Institute, St. Petersburg, Russia)

  Prepared by Dale Kaiser (CDIAC) and Daria Scott (St. Cloud State University summer student); June 2003.

  Data have been updated through 2002. The values were taken mainly from the World Weather Records, Monthly Climatic Data for the World, and Meteorological Data for Individual Years over the Northern Hemisphere Excluding the USSR, supplemented with information from different national publications. This update of the series through 2002 shows that the northern hemisphere has warmed at a rate of +0.65°C/100 yrs, and the southern hemisphere (0°-60°S) at a rate slightly greater than +0.54°C/100 yrs. The most recent year of the data record, 2002, set several seasonal/regional records for warmth: (1) the highest globally-averaged winter (+0.75°C) and autumn (+0.62°C) temperature anomalies; (2) the highest northern hemisphere winter temperature anomaly (+1.14°C); and (3) the highest winter temperature anomaly for the 30-60°N latitude band (+1.74°C).

- **Atmospheric CO_2 records from sites in the SIO air sampling network**
  http://cdiac.ornl.gov/trends/co2/sio-keel.htm

  Contributors: C. D. Keeling and T. P. Whorf (Scripps Institution of Oceanography, University of California)

Updated by Tom Boden, CDIAC; July 2003.

The Mauna Loa atmospheric CO_2 measurements, which began in 1958, constitute the longest continuous record of atmospheric CO_2 concentrations available in the world. The Mauna Loa site is considered one of the most favorable locations for measuring undisturbed air because possible local influences of vegetation or human activities on atmospheric CO_2 concentrations are minimal and any influences from volcanic vents may be excluded from the records. The methods and equipment used to obtain these measurements have remained essentially unchanged during the 4-decade-long monitoring program. The Mauna Loa record shows an 18% increase in the mean annual concentration, from 315.98 parts per million by volume (ppmv) of dry air in 1959 to 372.95 ppmv in 2002. The increase in mean annual concentration from 2001 to 2002 was 2.06 ppmv (the largest single yearly jump in the Mauna Loa record was the 2.87 ppmv increase from 1997 to 1998). The records have also been updated through 2002 for the SIO sites at Barrow (Alaska), Capa Matatula (Samoa), South Pole (Antarctica), and Alert (Northwest Territories, Canada).

- **Global, Hemispheric, and Zonal Temperature Deviations Derived from Radiosonde Records**
  http://cdiac.ornl.gov/trends/temp/angell/angell.html

  Contributors: James Angell (NOAA Air Resources Laboratory, Silver Spring, Maryland**)**

  Updated by Sonja Jones and Dale Kaiser, CDIAC; August 2003.

  Data from a global network of 63 radiosonde stations were used to estimate temperature deviations from 1958 through 2002. These estimates are categorized vertically (for the near-surface, troposphere, tropopause, low stratosphere, and the near-surface up to 100 mb) and horizontally (for the globe, the Northern and Southern Hemispheres, and the North and South Polar, North and South Temperate, North and South Subtropical, Tropical, and Equatorial latitudinal zones). Based on this network, Angell reported that during 1958-2002 the global mean, near-surface air temperature warmed by 0.16°C/decade and the 850-300 mb troposphere layer warmed by 0.08°C/decade. The global mean 300-100 mb tropopause layer cooled by approximately -0.20°C/decade, driven mainly by large changes in the Polar zones, and the 100-50 mb low-stratospheric layer experienced a global mean cooling of about -0.60°C/decade.

- **Global, Regional, and National Fossil Fuel CO_2 Emissions**
  http://cdiac.ornl.gov/trends/emis/em_cont.htm

  Prepared by: Gregg Marland and Tom Boden (CDIAC) and Bob Andres (University of North Dakota); August 2003.

  CDIAC staff compiled estimates of CO_2 emissions from fossil-fuel combustion and cement production, on global, regional, and national scales for 1751-2000. The estimate for 2000 global CO_2 emissions, 6611 million metric tons of carbon, represents a 1.8% increase from 1999. These estimates, derived primarily from energy statistics published by the United Nations, were calculated using the methods of Marland and Rotty (1984). Cement production estimates from the U.S. Department of Interior's Bureau of Mines were used to estimate CO_2 emitted during cement production. Emissions from gas flaring were

derived primarily from U.N. data but were supplemented with data from the U.S. Department of Energy's Energy Information Administration, Rotty (1974), and with a few national estimates provided by Marland.

- **Monthly carbon isotope (C-13) summaries based on data from the worldwide network of the Commonwealth Scientific Industrial and Research Organization (CSIRO)**
  http://cdiac.ornl.gov/trends/co2/allison-csiro/allcsiro_gaslab.html

  Contributors: Colin Allison, Roger Francey, and Paul Krummel (Commonwealth Scientific and Industrial Research Organisation, Australia)

  Prepared by T.J. Blasing and Sonja Jones, CDIAC; September 2003.

  Data are available from nine sites: Alert (Northwest Territories) and Estevan Point (British Columbia), Canada; Cape Ferguson, Cape Grim (Tasmania), and Macquarie Island, Australia; Mauna Loa (Hawaii); Mawson and South Pole, Antarctica; and Shetland Islands, Scotland. The lengths of these records vary from site to site, but are typically around ten years and run through 2001 (except at the South Pole, where December 2001 data are not yet available).

3.4. Newsletters, Reports, and Additional Online Publications

- ***Fiscal Year 2002 Annual Report*** (ORNL/CDIAC-139)
  http://cdiac.ornl.gov/epubs/cdiac/cdiac139/2002annrpt.html

  Contributors: Robert M. Cushman, Thomas A. Boden, Leslie A. Hook, Sonja B. Jones, Dale P. Kaiser, Alexander Kozyr, and Tommy Nelson, CDIAC

  Prepared by Carolyn Householder, CDIAC; July 2003.

  The report documents highlights from the fiscal year (new data products and other publications) and provides information on CDIAC, which includes the World Data Center for Atmospheric Trace Gases. The report provides information of relevance to CDIAC focus areas (i.e., AmeriFlux, NARSTO, FACE, Oceans); provides statistics, such as the number of requests for global change data and information from CDIAC and citations in the published literature of data obtained from CDIAC; alerts users to new data products (publications and databases) that CDIAC hopes to release in the new fiscal year; lists awards received by CDIAC and publications and presentations of its staff; lists the many organizations with which CDIAC has collaborated to produce the data and information products it released in the current fiscal year; a staff listing; and an acronym and abbreviation list.

- **Publications, Presentations, and Awards (ORNL/CDIAC-101)**
  http://cdiac.ornl.gov/epubs/cdiac/cdiac101/pubslist.htm

  Updated by Bob Cushman, CDIAC; March 2003.

  Bob Cushman updated the online listing of CDIAC's "Publications, Presentations, and Awards" ORNL/CDIAC-101 (*http://cdiac.ornl.gov/epubs/cdiac/cdiac101/pubslist.htm*).

- **The GLODAP (GLobal Ocean Data Analysis Project) Atlantic Ocean atlas for carbon-related parameters** *http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm*

  Prepared by Alex Kozyr, CDIAC; June 2003.

  GLODAP is a cooperative effort to coordinate global synthesis projects funded through NOAA/DOE and NSF as part of the Joint Global Ocean Flux Study - Synthesis and Modeling Project (JGOFS-SMP). Cruises conducted as part of the World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Study (JGOFS) and NOAA Ocean-Atmosphere Exchange Study (OACES) over the decade of the 1990s have created an oceanographic database of unparalleled quality and quantity. These data provide an important asset to the scientific community investigating carbon cycling in the oceans. The central objective of this project is to generate that unified data set to help determine the global distributions of both natural and anthropogenic inorganic carbon, including radiocarbon. These estimates provide an important benchmark against which future observational studies will be compared. They also provide tools for the direct evaluation of numerical ocean carbon models.

- **Name that compound: The numbers game for CFCs, HFCs, HCFCs, and Halons**
  http://cdiac.ornl.gov/pns/cfcinfo.html

  Prepared by T.J. Blasing and Sonja Jones, CDIAC; August 2003.

  Confused by the nomenclature of halogenated hydrocarbons, which are important in both the climate-change and ozone-hole issues? For example, do you wonder what the number in "11" in CFC-11 means? This information explains how to find the number, given the chemical formula, and how to find the chemical formula, given the number.

3.5 What's Coming in FY 2004

CDIAC is currently working on, or has completed, the following new or existing data and information products for FY 2004.

- ***CDIAC Communications.*** **Issue Number 30**
  http://cdiac.ornl.gov/newsletr/october2003/cc30.pdf

  Edited by Sonja Jones, CDIAC; October 2003.

  CDIAC published the 2003 issue (#30) of CDIAC's newsletter, *CDIAC Communications*. This issue featured the lead story by Mike Farrell, "A Vision for Climate Change Data Management". The newsletter also lists new and updated global-change data and information products made available since

Issue #29 and provides information relevant to CDIAC's Focus Area Outreach (i.e., AmeriFlux, NARSTO, Oceans, FACE).

- The ALE/GAGE /AGAGE Network. DB1001 (Updated and Revised November 2003)
- Current Greenhouse Gas Concentrations (Revised November 2003)

CDIAC continually expands *Trends Online* with new records and updates to existing records. Remember to check the "New" page on our Web site (*http://cdiac.ornl.gov/new/new.html*) for announcements of the latest CDIAC data and information products.

4. Information Services

4.1 FY 2003 Statistics

Statistics reflecting CDIAC's FY 2003 Web activity were calculated using the Web analysis tool, NetTracker® (Sane Solutions, LLC). CDIAC continues to receive and respond to user requests through email, mail, fax, and the telephone, and users continue to access our data products through direct FTP; however, statistics in these areas total in the hundreds as compared to the statistics reflecting CDIAC's Web site activity.

In FY 2003, 317,000 unique hosts visited CDIAC's Web site (Figure 4.1) using 291 browsers. The browsers of choice were the various versions of Microsoft Internet Explorer, Netscape Navigator, and America Online, respectively. During FY 2003, CDIAC's Web site received more than 578,000 visits from users who viewed over 3.2 million Web pages (Figure 4.2). The number of visits to CDIAC's Web site increased 9%, whereas the number of pages viewed decreased by 9%. The average number of pages accessed per day decreased in FY 2003 from 8,900 to 7,900. The average visit to CDIAC's Web site lasted ten minutes. A view is defined by NetTracker® as a hit to a Web page, excluding user defined files (CDIAC excludes such files as .jpg, .gif, etc.). A visit is defined as a series of consecutive views of a Web site by the same unique host within a specified period of time.

Visits to CDIAC's Web site were made from 121 different domains (Figure 4.3) with the top domain being the U.S. Commercial sector (28.7%). Of the 121 domains, 112 domains represented hosts from foreign countries (Figure 4.4).

Net Tracker® statistics indicate that 41% of the visits to the CDIAC Web site were the result of direct links (i.e., the user either typed the CDIAC URL or has the CDIAC WWW site "bookmarked"). Visits resulting from indirect hits (e.g., via the use of search engines such as google.com, Yahoo, msn.com, etc.) were 59% of the total visits.

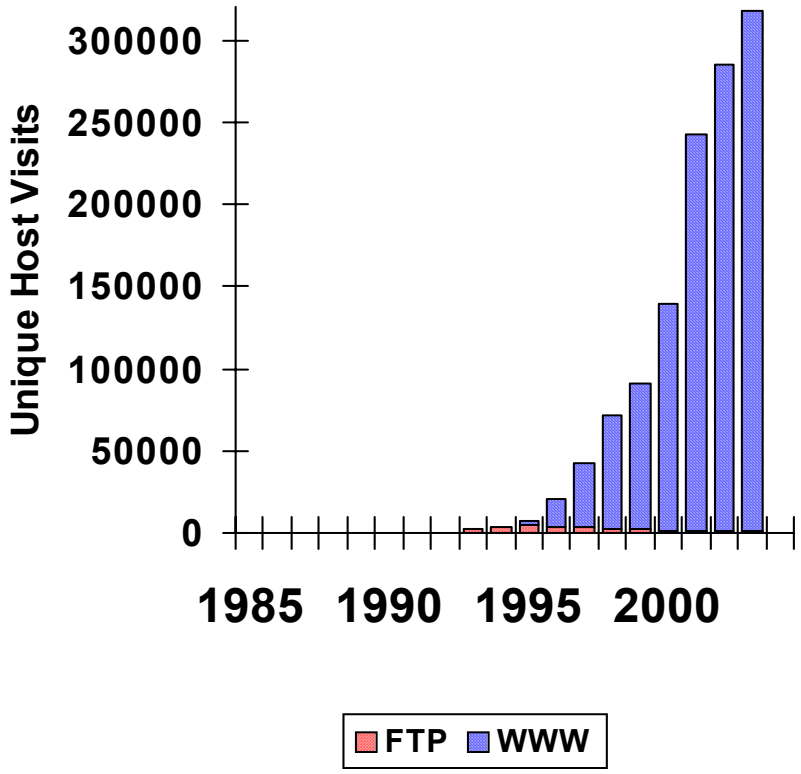
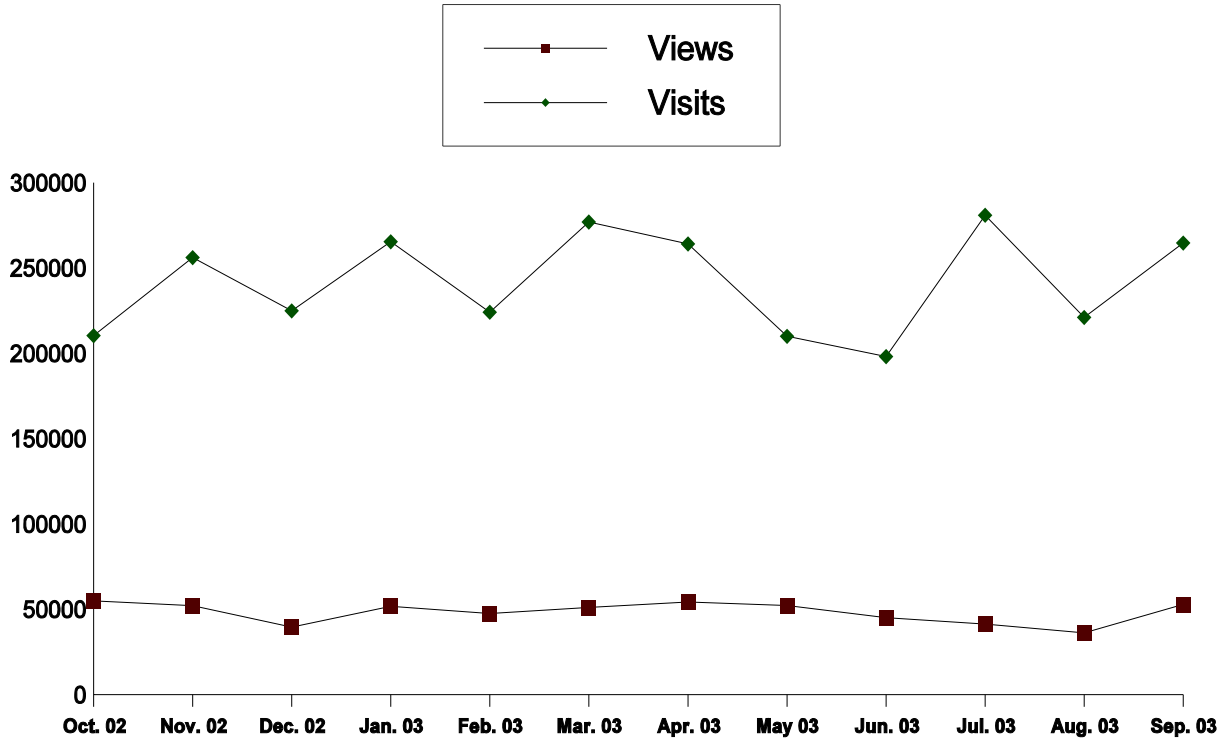


Figure 4.1 Web Activity of Unique Host Visits, FY 1985 - FY 2003.

CDIAC's audience of worldwide users includes:

- educators (teachers, professors),
- students (elementary, high school, college graduate, undergraduate, and postgraduate),
- general public (interested citizens, special interest groups),
- specialists (scientists, engineers, business and industry),
- government (legislative assistants, policymakers, agencies), and
- media (radio, television, newspapers).

Figure 4.2 Comparison of Views/Visits for FY 2003.



NOTE:

- A view is defined by NetTracker® as a hit to a Web page, excluding user-defined files (CDIAC excludes such files as .jpg, .gif, etc.).
- A visit is defined as a series of consecutive views of a Web site by the same unique host within a specified period of time.

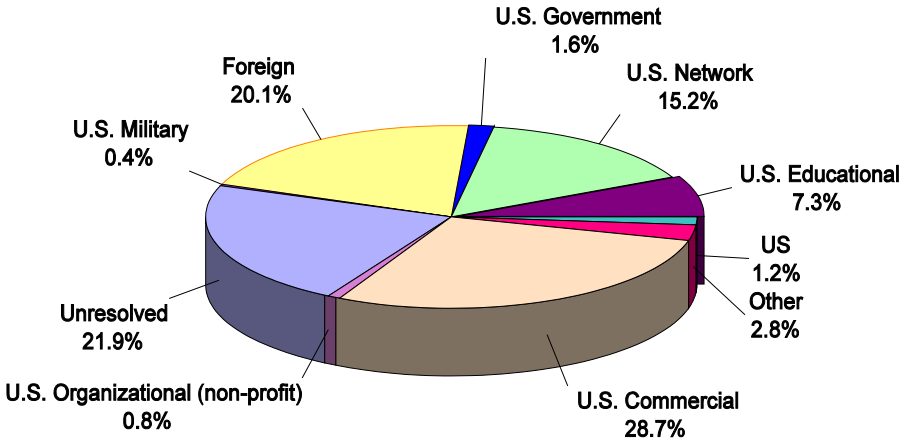


Figure 4.3 Analysis of Web Site Visits by User Domain.

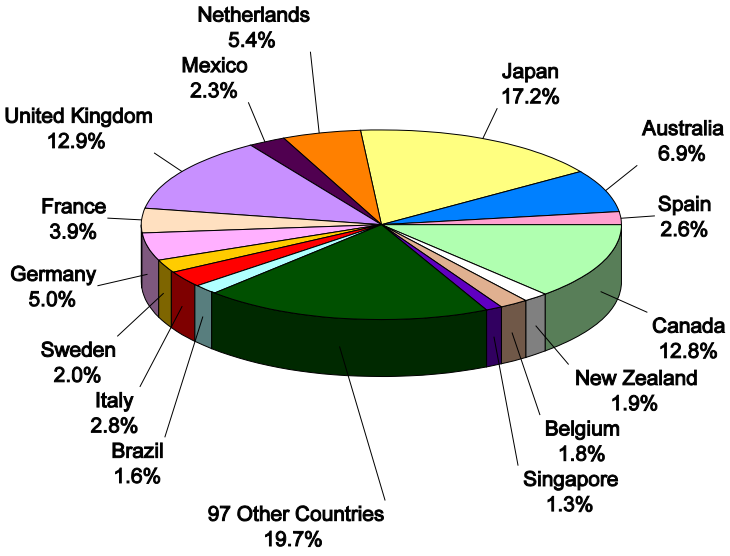


Figure 4.4 Analysis of Web Site Visits Representing Foreign Countries.

5. Computer Systems Development

CDIAC's computer systems development team continues to search for ways to improve our operation and increase efficiency. To keep pace with the proliferation of data and increasing global interest in climate change data, we must continue to anticipate the impact of emerging information technologies and position ourselves to apply those technologies to meet the needs of our global user community.

5.1 Infrastructure Improvements

We replaced four desktop systems that had proven problematic.

5.2 Live Access Server (LAS)

We completed installation and configuration of the Live Access Server (LAS). The LAS is a highly configurable Web server application designed to provide flexible access to geo-referenced oceanographic data. The new server, comprised of a Dell PowerEdge 1650 rack mounted server and 200 gigabytes of RAID storage, will run LAS under the Red Hat Linux operating system. We also completed installation of the software needed to support the LAS and to support LAS functionality. The installation and configuration of the LAS software was labor intensive requiring several weeks. Approximately 50 data sets, comprised of both gridded and bottle data, were loaded and are accessible through the LAS system (http://cdiac3.ornl.gov/las/servlets/dataset**)**.

5.3 CDIAC Implementation of Mercury

We implemented a public version of the CDIAC instance of Mercury (http://mercury.ornl.gov/cdiac/). Mercury, developed at ORNL, is a data search and retrieval system that uses metadata to perform very accurate searches. Mercury provides users with sophisticated data search tools, including dynamic pick lists, spatial, temporal, and fielded search capabilities. Users can select CDIAC products by product number, product title, author, subject area, keyword, or user-supplied text. Along with the metadata enhancements also completed, this system greatly improves our user community's ability to quickly locate and access CDIAC data products.

5.4 CDIAC ORNL Metadata Editor (OME) Tools

Several enhancements to the ORNL Metadata Editor (OME) were completed during FY 2003 by Stan Attenberger (OME developer and member of the ORNL NASA Distributed Active Archive Center) with benefits to the CDIAC OME . OME is a Web-based tool that allows users to create and maintain XML files containing key information or metadata, about the data set. The CDIAC OME is used by CDIAC staff to input information about CDIAC data sets. The resulting XML files serve as source files for the CDIAC Mercury instance described above. Among the many enhancements were: 1) a simplified OME edit page, combining the two top frames into one frame, allowing more information to be displayed on the form. 2) Redesigned form controls to improve clarity. 3) Added form navigation aides such as "terse" and "verbose" modes. 4) Added multi-color background to permit "mark" option, facilitating form navigation. 5) Added "Find Item" option.

5.5 Computer Systems Maintenance and Updates

We also spent a considerable amount of time performing necessary routine functions in support of the CDIAC Computing System Network. These tasks included backing up nightly, upgrading/replacing disk drives, creating new file systems, installing/upgrading application software and operating system enhancements, restoring user-deleted files, installing/replacing uninterruptible power supplies, assisting CDIAC staff with computing problems, producing Web statistics, making wholesale Web changes, providing Web design direction, and maintaining the Web development area and all related servers. Cyber security is a focal area to ensure no CDIAC computing systems are open to compromise. Stringent requirements were implemented at ORNL including frequent, periodic testing. Any deficiencies or perceived deficiencies must be addressed immediately. It is ORNL policy to remove from the network any systems failing to fully comply with security guidelines.

5.6 Carbon Sequestration Web Server

We continue to operate the server for the Carbon Sequestration Web site, at the request of DOE program management. In FY 2003, this Sun workstation-based system received 122,895 requests from 75 countries around the world and averaged 339 visits per day.

5.7 Plans for FY 2004

Based on system improvements implemented at CDIAC, we continue to take full advantage of evolving computing and information management technologies. We have plans to continue building upon several information management tools under continuing development at ORNL. We are excited by what these tools will offer our user community and look forward to another productive year in FY 2004.

We will replace the venerable CDIAC Web and ftp server. This will entail moving from a Sun/Solaris hardware/software combination to an expandable Intel/Linux combination. This will necessitate the implementation of Red Hat's Enterprise Server release of Linux, rebuilding and reloading software applications, off-loading applications to one of our remaining Sun/Solaris platforms when rebuilding/ reloading to the new Intel platform is not possible, porting, testing and in some cases re-writing scripts to execute under Linux, and finally restructuring file systems to utilize RAID 5 storage.

Red Hat has announced they will no longer support Linux version 7.1-8.0 as of 12/31/2003 nor version 9.0 as of 4/30/2004. We will migrate user desktop Linux systems to the Red Hat Enterprise Linux WS operating system. Server class machines, including all Web servers and the LAS server, will be migrated to the Red Hat Enterprise Linux ES operating system.

The Carbon Sequestration Web site will be moved to the new CDIAC server and assigned a new IP address. This is necessary due to the aging, unreliable hardware previously supporting the Carbon Sequestration Web site.

We will assume operation of the CSiTE Web server. The CSiTE server will be moved to the new CDIAC server and assigned a new IP address. This is necessary due to the age of the hardware previously supporting the CSiTE Web site and departure of ESD staff previously operating the server.

We will implement a tabbed interface for the CDIAC instance of Mercury. The tabbed interface offers a very clean presentation of Mercury providing separate pages for spatial, temporal, and keyword searches.

We will work with members of the International Ocean Carbon Coordination Project (IOCCP) to determine the feasibility of developing an instance of Mercury to serve metadata and data to members of the IOCCP worldwide. We will develop presentation materials on Mercury's capabilities and the proposed system to be presented at the International Workshop on Ocean Surface pCO_2, Data Integration and Database Development, January 14-17, in Tsukuba Japan.

We will implement a data management paradigm based on XML file creation. This paradigm will establish new procedures and provide the tools needed to allow CDIAC staff to chronicle data from receipt to final publication.

We plan to replace two of our aged user machines as part of a programmed obsolescence rotation. System replacements will be subject to fund availability.

The current version of NetTracker, the software we use to track Web usage, must be updated to remain compliant with operating system upgrades. Due to dramatic increases in the cost of this product, and our need for improved functionality, we plan to replace our current Web log analysis software with WebTrends Log Analyzer. WebTrends Log Analyzer was chosen after an evaluation of alternatives, conducted in FY 2003.

We will explore the feasibility of moving our newsletter, *CDIAC Communications*, from a traditional publication to a virtual publication.

We will evaluate options for updating the format of the CDIAC homepage.

6. CDIAC Presentations, Publications, and Awards

6.1 Presentations

- Gregg Marland attended the Sixth International Conference on Greenhouse Gas Control Technologies (*http://www.ieagreen.org.uk/ghgt6.htm*) in Kyoto, Japan. He presented a paper (co-authored with Charles Garten, Mac Post, and Tris West of the ORNL Environmental Sciences Division) on carbon sequestration in the terrestrial biosphere.

- Alex Kozyr attended the 11th annual meeting of PICES (*http://www.pices.int/index.asp*), the North Pacific Marine Science Organization, held in Qingdao, China. He took part in the Working Group 17 (CO_2 in the North Pacific) and Technical Committee on Data Exchange meetings. During the WG-17 meeting, the traveler presented a new Web site that was developed at CDIAC for the Global Ocean Data Analysis Project (*http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm*). A North Pacific database for ocean CO_2 and related parameters, written documentation of best practices for ocean CO_2 measurements, and coordination of future North Pacific measurement programs were discussed during the WG-17 meeting.

- T.J. Blasing presented "Refinements in the spatial and temporal resolution of fossil-fuel CO_2 emissions data" at the Annual Meeting of the American Geophysical Union in San Francisco. The paper, co-authored by summer student Christine Broniak (Pennsylvania State University) and Gregg Marland, offers preliminary estimates of fossil fuel CO_2 emissions for the entire USA on a month-by-month basis, and for each state on an annual basis, for the most recent 20 years. Increasing sophistication of inverse models of the carbon cycle and more detailed understanding of carbon fluxes require finer spatial and temporal resolution than had been previously available. The methodology for obtaining the emissions estimates is similar to what has been used previously to estimate global and national annual totals, but relies on more detailed data by fuel type and end use.

- Tom Boden presented "AmeriFlux Data Management Activities" and Lianhong Gu presented "Standardizations and automation of the u* method for nighttime flux correction"at the Annual AmeriFlux Science Meeting in Boulder (October 22-23).

- Dale Kaiser presented "Changes in Characteristics of United States Snowfall Over the Last Half of the Twentieth Century" at the 83rd Annual Meeting of the American Meteorological Society (Long Beach, California), as part of the *14th Symposium on Global Change and Climate Variations*. The paper was co-authored with Daria Scott (CDIAC summer intern from St. Cloud State University, Minnesota). The authors used daily snowfall data from the U.S. Historical Climatology Network (produced by the National Climatic Data Center, quality-assured and published by CDIAC) to look at trends in several snowfall variables over 1948 ! 2001. The most dramatic findings reveal large decreases in the number of snowfall days, total snowfall, and percentage of total precipitation attributable to snowfall over the Pacific Northwest. These trends represent important regional climate change; one of the most practical effects being the resulting impact on snowpack and associated water supply.

- Gregg Marland spoke on "Sequestration in the terrestrial biosphere" at The American Association for the Advancement of Science Annual Meeting (Denver, Colorado; *http://www.aaas.org/meetings/*). DOE's National Energy Technology Laboratory organized two symposia, "Comparative Assessment of Carbon Sequestration as a Greenhouse Gas Mitigation Strategy" and "Climate Change Mitigation

Strategy and Technical Challenges for Carbon Sequestration," as part of the "Dealing with Global Change" track.

- Tom Boden was an invited speaker at the U.S. Climate Change Science Program (USCCSP) Planning Workshop for Scientists and Stakeholders in Washington, D.C. Tom's presentation was a review and critique of the "Climate Quality Data Management Systems" element of the USCCSP.

- "Towards better access to, and safekeeping of, oceanic CO_2 and carbon data: Data collection for the CDIAC and WDC-MARE databases during ORFOIS," a poster by Dorothee Baker, Ute Schuster, and Andrew Watson (University of East Anglia, Norwich, UK); Nicolas Dittert (Institut Universitaire Europeen de la Mer, Plouzane, France); and Alex Kozyr (CDIAC), was presented at the 2nd CARINA (Carbon in the North Atlantic) general meeting and open science conference (Las Palmas, Canary Islands). The marine carbon cycle plays a central role in the oceanic CO_2 absorption. As part of the European Union project ORFOIS (ORigin and Fate of biogenic particle fluxes in the Ocean and their Interactions with the atmospheric CO_2 concentrations, as well as the marine Sediment), scientists are working towards better access and storage of global oceanographic carbon data by retrieving scattered data and contributing them to international, publicly-accessible databases. The project collaborates with CDIAC and the German World Data Centre for Marine Environmental Sciences (WDC-MARE, *http://www.wdc-mare.org/*). Surface water pCO_2 data (with accompanying pH, TCO_2 and alkalinity, if available) will be contributed to the Underway pCO_2 Data Inventory at CDIAC. All other organic and inorganic carbon data will be stored in the PANGEA database (*http://www.pangaea.de/*), which WDC-MARE maintains. Alex also presented "Global Ocean Data Analysis Project (GLODAP) Results and Data," co-authored with Christopher Sabine (University of Washington), Richard Feely and John Bullister (NOAA Pacific Marine Environmental Laboratory), Robert Key (Princeton University), Rik Wanninkhof and Tsung-Hung Peng (NOAA Atlantic Ocean Marine Laboratory), and Frank Millero (University of Miami).

- Carolyn Householder presented "CDIAC Data and Information for Global Warming and Climate Change: An Earth Day Perspective" at the Ewing Park Middle School, Metro Davidson County Schools, Nashville, Tennessee, as part of Earth Day observation on April 22. She gave an overview of greenhouse gases and trends in global warming and climate change.

- Les Hook and Sig Christensen presented posters about NARSTO's tropospheric ozone and particulate matter research and distributed CDs of the new NARSTO assessment, "Particulate Matter Science for Policy Makers" (*http://cdiac.ornl.gov/programs/NARSTO/*) at the Regional Clean Air Action Summit (Knoxville, Tennessee).

- "The annual cycle of fossil-fuel emissions from the United States" was the title of a paper presented by T. J. Blasing at the Climate Monitoring and Diagnostics Laboratory Annual Meeting (Boulder, Colorado). An abstract appears on page 18 of "*Climate Monitoring & Diagnostics Laboratory: Annual Meeting, April 30 - May 1, 2003, Boulder Colorado*."Co-authors were Gregg Marland and Christine Broniak; Ms. Broniak was a summer student in 2002 (from Pennylvania State University) and returned the summer of 2003. Monthly CO_2 emissions of CO_2 from fossil-fuel combustion reveal a clear annual pattern in total emissions, as well as in the percentages attributable to coal, oil, and natural gas. These results suggest an annual pattern in the carbon-13 signature of emissions, which would be useful in tracking carbon fluxes to and from the atmosphere. The 20% increase in emissions since 1981 is most evident in the summer, the low part of the annual cycle; consequently, the amplitude of the annual cycle appears to be decreasing. Electronic copies of the abstract are available on request.

- Gregg Marland attended the first meeting of lead authors of the IPCC (Intergovernmental Panel on Climate Change) Special Report on Carbon Dioxide Capture and Storage (Oslo, Norway). The report, which is scheduled for release in the first half of 2005, will address the myriad of alternatives (other than sequestration of carbon in the terrestrial biosphere, which was considered in a 2001 IPCC report) for collecting and storing the CO_2 that would otherwise be discharged from fossil fuel consumption to accumulate in the atmosphere as a greenhouse gas. The questions to be addressed are how carbon sequestration might be accounted for in the context of international agreements to limit greenhouse gas emissions, and how these accounts might deal with issues such as the permanence of sequestration. Gregg also participated in a workshop at the Aspen Global Change Institute in Colorado to discuss long-term technology pathways to stabilize greenhouse gas concentrations. He spoke on the opportunities for carbon sequestration in the biosphere, suggesting that this could make a significant contribution in the near term even though it was clearly not a long-term "green bullet." An attempt is being made to collect a comparable set of information on all of the options presented so that some comprehensive summary and comparison can be constructed.

6.2 Publications

- Roger Pielke (Colorado State University), with Gregg Marland and other co-authors, published "The influence of land-use change and landscape dynamics on the climate system relevance to climate-change policy beyond the radiative effect of the greenhouse gases" in the *Philosophical Transactions of the Royal Society of London* (series A, Volume 360, p. 1705 ! 1719, 2002). The paper shows how land-use change affects regional and global climate through the surface energy budget, an effect that may be more important than changes mediated through the carbon cycle. The paper suggests a substitute for Global Warming Potential, which does not quantify direct land-use impacts on climate.

- "Decreasing trends in sunshine duration over China for 1954 ! 1998: Indication of increased haze pollution?" by Dale Kaiser, with Yun Qian (Pacific Northwest National Laboratory), was published in the November 2002 issue of *Geophysical Research Letters* (Volume 29:21, *http://www.agu.org /journals/gl/*). Significant decreases in sunshine duration over China (especially the eastern half of the country) have been observed since 1980, apparently related to increased loading of anthropogenic aerosols; the decreased duration and intensity of sunshine seem to have lowered maximum summertime temperatures. The editors of GRL selected this paper as an "*AGU Journal* Highlight" and distributed a press release ("China cools under an aerosol haze") in advance of the paper's publication.

- Alex Kozyr co-authored "In situ calcium carbonate dissolution in the Pacific Ocean" (R.A. Feely, et al.), which appeared in *Global Biogeochemical Cycles*, Volume 16:4. The paper describes the synthesis of a Pacific Ocean data set with over 35,000 sample locations, to better understand oceanic carbon cycling processes. The authors estimate an average carbonate dissolution rate of about 0.31 petagrams of carbon per year**.**

- Eric Marland (Appalachian State University, North Carolina) and Gregg Marland published "The treatment of long-lived, carbon-containing products in inventories of carbon dioxide emissions to the atmosphere" in the journal *Environmental Science & Policy* (Volume 6:2, p. 139 ! 152). Some fractions of fossil-fuels and harvested wood are incorporated into products that have lifetimes ranging from months to centuries. The IPCC methodology for estimating greenhouse-gas emissions assumes that some fraction goes to permanent storage while the remainder is oxidized instantly. A description of annual stock changes needs to consider how both production and oxidation evolve with time.

- Bob Cushman published "Additivity of state inventories of greenhouse-gas emissions" in the journal *Environmental Management* (Volume 31:2, p. 292 ! 300). This paper analyzes state inventories of emissions of carbon dioxide, methane, and nitrous oxide in the United States. Reanalysis of the state inventories is required before they can be added to yield a larger-scale inventory. Some specific sources were considered by some states but not by others. There are instances of both double-counting (two states reporting the same emission) and omission (neither state reporting the same emission), where interstate transfers of energy or materials occurred. The inventories, when adjusted for obvious double-counting or omissions, are approximately additive.

- Lianhong Gu and Tom Boden (Oak Ridge National Laboratory), Dennis Baldocchi (University of California, Berkeley), Steve Wofsy, William Munger, and Shawn Urbanski (Harvard University), and Joseph Michalsky (State University of New York, Albany), published "Response of a deciduous forest to the Mt. Pinatubo eruption: Enhanced photosynthesis" in the journal *Science* (Volume 299:5615, p. 2035 ! 2038). They found that the increase in diffuse radiation from the 1991 eruption enhanced noontime clear-sky photosynthesis of the Harvard Forest (Massachusetts) by 23% and 8% in 1992 and 1993, respectively. This enhancement of photosynthesis would have increased the terrestrial carbon sink and suppressed the growth rate of atmospheric carbon dioxide.

- "Evidence for recent changes in a surface-air warming singularity in late winter over central North America," by T. J. Blasing, Daria Scott, and Dale Kaiser, was published in the May, 2003 issue of *Geophysical Research Letters* (V. 30:9). Ms. Scott was a summer student in 2001 and 2002 (from St. Cloud State University, Minnesota) and returned to CDIAC during the summer of 2003. Analysis of daily temperature data for central North America reveals a tendency for certain meteorological aspects of the winter-spring-summer transition to occur earlier in recent years. One example of this is a recent decrease in the number of strong, cold, high-pressure systems moving from western Canada into the north-central United States in mid- to-late February. This change does not seem closely linked to global warming, but may be related to thermal state of the North Pacific Ocean surface.

- Gregg Marland (with several co-authors) published "The climatic impacts of land surface change and carbon management, and the implications for climate-change mitigation policy" in Vol. 3:2 of the journal *Climate Policy* (*www.climatepolicy.com*). Carbon sequestration in the terrestrial biosphere affect surface albedo, fluxes of sensible and latent heat to the atmosphere, and the distribution of energy within the climate system, thereby altering the local, regional, and global climate. It is important to consider all of the effects of changes in terrestrial vegetation and to work toward a better understanding of the full climate system.

6.3 Awards and Kudos

CDIAC has been very active in the Smoky Mountain Chapter of the American Meteorological Society. T.J. Blasing is the outgoing secretary/treasurer, and Dale Kaiser is the president-elect of the chapter, per the February 2003, elections.

7. Selected CDIAC Citations

The following citations are examples of how CDIAC products are used and cited.

NDP-030, NDP-050:

Marland, E., and G. Marland. 2003. The treatment of long-lived, carbon-containing products in inventories of carbon dioxide emissions to the atmosphere. *Environmental Science & Policy* 6:139-152.

Trends:

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8. CDIAC Collaborations

CDIAC realizes that it would not be possible to produce global-change data and information products without the generosity and cooperation of researchers at institutions throughout the United States and around the world. In this annual report, we have noted the collaborating individuals and institutions for each product. Listed below are the many institutions that have collaborated with CDIAC in the publication of the databases and other information products described in this report.

8.1 DOE Laboratories

- Brookhaven National Laboratory
- Argonne National Laboratory

8.2 Other Federal Agencies

- Department of Agriculture
- NOAA Air Resources Laboratory (ARL)
- NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML)
- NOAA Climate Monitoring and Diagnostics Laboratory (CMDL)
- NOAA Pacific Marine Environmental Laboratory (PMEL)
- U.S. Forest Service

8.3 Universities/Research Institutions

- Colorado University
- Florida International University
- Georgia Institute of Technology
- Harvard University
- Indiana University
- Lamont-Doherty Earth Observatory of Columbia University
- Laval University
- Massachusetts Institute of Technology
- Monterey Bay Aquarium Research Institute
- National Institute for Global Environmental Change (NIGEC) National Office (University of California, Davis)
- Ohio State University (OSU)
- Oregon Graduate Institute of Science and Technology
- Oregon State University
- Portland State University
- Princeton University
- Rosenstiel School of Marine and Atmospheric Sciences, University of Miami
- Scripps Institution of Oceanography (SIO), University of California, San Diego
- University of Alberta
- University of British Columbia

- University of California, Berkeley
- University of Florida
- University of Hawaii
- University of Nebraska ! Lincoln
- University of New Hampshire
- University of North Dakota
- University of Sao Paulo
- University of South Florida
- Woods Hole Oceanographic Institution

8.4 Foreign Collaborators

- Arctic and Antarctic Research Institute, Russia
- Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
- Hadley Centre for Climate Prediction and Research, United Kingdom
- Institute of Geography, Russia
- Institute of Ocean Science, Canada
- Instituto Español de Oceanografía, Spain
- International Science Consultants, United Kingdom
- Laboratoire de Glaciologie et Géophysique de l'Environnement, France
- Laboratoire des Sciences du Climat et de l'Environnement, France
- University of East Anglia, United Kingdom

9. Acronyms and Abbreviations

AGAGE	Advanced Global Atmospheric Gases Experiment
ALE	Atmospheric Lifetime Experiment
AmeriFlux	Eddy Covariance Flux Network in North, Central, and South America
AOML	Atlantic Oceanographic and Meteorological Laboratory
CARINA	CARbon dioxide In the North Atlantic ocean
CAS	Chemical Abstracts Service
CDIAC	Carbon Dioxide Information Analysis Center
CFCs	chlorofluorocarbons
CMP	computer model package
CMDL	Climate Monitoring and Diagnostics Laboratory
CO_2	carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTD	conductivity, temperature, and depth
DAAC	Distributed Active Archive Center
DB	database
DES	Data Exchange Standard
DIST	Data and Information Sharing Tool
DMHB	Data Management Handbook
DOE	U.S. Department of Energy
EC	eddy covariance
EPA	U.S. Environmental Protection Agency
ESD	Environmental Sciences Division
FACE	Free-Air CO_2 Enrichment
FTP	File Transfer Protocol
FY	fiscal year
GAGE	Global Atmospheric Gases Experiment
GCDIS	Global Change Data and Information System
GLODAP	GLobal Ocean Data Analysis Project
GTS	Global Telecommunications System
HFCs	Hydrofluorocarbons
HCFCs	Hydrochlorofluorocarbons
HTML	Hypertext Markup Language
IPCC	Intergovernmental Panel on Climate Change
JGOFS	Joint Global Ocean Flux Study
JODC	Japan Oceanographic Data Center
LAI	leaf area index
LAS	Live Access Server
MEDS	Marine Environmental Data Service (Canada)
Mg	Megagram
MODIS	moderate-resolution imaging spectro-radiometer
NARSTO	*formerly* North American Research Strategy for Tropospheric Ozone
NASA	National Aeronautics and Space Administration
NDP	numeric data product
NEP	net ecosystem production

NIGEC	National Institute for Global Environmental Change
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NPP	net primary production
NSF	National Science Foundation
OACES	Ocean-Atmosphere Carbon Exchange Study
ODS	Output Delivery System
OME	ORNL Metadata Editor
OROFOIS	ORigin and Fate of biogenic particle fluxes in the Ocean and their Interactions with the atmospheric CO_2 concentrations, as well as the marine Sediment
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
pCO_2	partial pressure carbon dioxide
PDA	permanent data archive
PDF	portable document format
Pg	petagram
pH	pH value
PICES	North Pacific Marine Science Organization
PIs	principal investigators
PM	particulate matter
PMEL	Pacific Marine Environmental Laboratory
ppmv	parts per million by volume
pptv	parts per trillion by volume
QPHB	*Quality Planning Handbook*
QSMP	*Quality Systems Management Plan*
QSSC	Quality Systems Science Center
R3	Request Response Record
RAID	redundant array of independent disk
R/V	Research Vessel
SAT	surface-air temperature
SF_5CF_3	trifluoromethyl sulphur pentafluoride
SF_6	sulphur hexafluoride
SIO	Scripps Institution of Oceanography
SOS	Southern Oxidants Study
SQL	Structured Query Language
TALK	total alkalinity
TCO_2	total carbon dioxide
TDE	Throughfall Displacement Experiment
UN	United Nations
UPS	uninterruptible power supply
URL	Universal Resource Locator
USCCSP	U.S. Climate Change Science Program
WBW	Walker Branch Watershed
WDC	World Data Center
WG	Working Group

WHP	World Hydrographic Program
WOCE	World Ocean Circulation Experiment
WWR	World Weather Records
XML	eXtensible Markup Language

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